REVIEW OF GROUND-WATER CONDITIONS IN THE BIG LOST RIVER VALLEY

by

Stanley P. Szczepanowski
Idaho Department of Water Resources
December 1982

Preface

This report was originally drafted in 1982, but was not completed for release prior to Mr. Szczepanowski's resignation. The report is now being issued in response to concerns relating to the issuance of additional water right permits. Hydrographs in the report have been updated to include more recent data and some minor editing of the text has been performed.

As discussed in this report, hydrologic studies performed by by Crosthwaite, et al. (1970a and b) clearly express the close and inseparable relationship that exists between the surface- and ground-water systems. Later work by the U.S. Geologic Survey supports this view. The degree of interconnection between them varies both spatially and temporally. To remove water from one, will eventually affect the other. Available geologic data indicate no laterally extensive confining layers exist that isolate the Big Lost River from a "deeper" ground-water system.

Most of the outflow leaving the basin occurs as ground-water underflow. Although estimates of the underflow vary, the figures imply that the total water resource would be adequate for present levels of use if distribution problems could be solved.

In order to mitigate conflicts between users, the surface- and ground-water resources of the basin should be managed conjunctively. A detailed plan needs to be developed with this in mind, before additional development should be allowed to occur and further aggravate the problems that currently exist.

Steven J. Baker
Idaho Department of Water Resources
May 1989

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

REVIEW OF GROUND-WATER CONDITIONS IN THE
BIG LOST RIVER VALLEY

Introduction

During the twenty years of the 1960's and 1970's, the use of ground water in the Big Lost River Valley has grown greatly. With this increase in use, came alterations of the hydrologic relationships and interactions between ground water and surface water. Recently, there have been concerns expressed for better water resource management; these have been made by both the public and by the Idaho Department of Water Resources (IDWR). Protests have been made to IDWR by water users who are alarmed by a number of applications for ground-water withdrawals. The fear is that new withdrawals will have adverse effects on other water users.

Purpose and Scope of Study

In order to advise IDWR administrators of the courses open for management of the water resources in the Big Lost River basin, the recommendations offered in the only available detailed basin studies (Crosthwaite, et al., 1970 a and b) were evaluated for their suitability and application. It must be recognized that the 1970 recommendations were developed from field work done from 1966 to 1969 and that no new field work directed in the search for new management ideas and options has been performed since 1969.

This report primarily attends to matters concerning ground water, even though the intimate connection between surface water and ground water is clearly presented numerous times in the 1970 reports; this finding of the importance of the connection is herein reinforced.

Past Studies

As part of a water resources study of the Snake River Plain in southeast Idaho, the Big Lost River basin was studied in the 1920's and 1930's (Stearns, et al., 1938). It was later investigated in detail by the U.S. Geological Survey (USGS) in the 1960's (Crosthwaite, et al., 1970). The mouth of the basin where it joins the Snake Plain aquifer was the subject of a study published in 1973 (Crosthwaite) and, more recently, the basin was examined as part of a water quality survey in five east-central Idaho valleys (Parliman, 1982).

Description of the Physical Environment

Location - The Big Lost River basin, 1400 square miles in area, is found centrally in the lower half of Idaho. More than 50 percent of the basin is situated in Custer County; this is the headwaters section. The lower portion is in Butte County. There is no actual mouth of the Big Lost River since the river seeps into the earth materials on the desert southeast of Arco and is completely lost to the ground water of the Snake River Plain in a variable length of river channel downstream from Arco where the river has left the Big Lost Valley and flows over the Snake River Plain.

The towns in the basin, listed in downstream order, include Chilly, Mackay, Leslie, Darlington, Moore and Arco. Mackay Reservoir, an impoundment on the Big Lost River, is located approximately three miles upstream from Mackay (Figure 1).

Climatology

The climatic character of the basin can be described as a continental type in which there is a large variability in seasonal and daily temperatures, in wind directions and velocities, and in precipitation. Monthly temperature means for the basin, at an elevation of 5897 feet (Mackay, Idaho), range from 16.9^{o} (January) to $66.8^{o}F$ (July); the annual mean is $42.1^{o}F$ (based on the period 1931-1960). At the higher elevations in the mountains, winds from the west generally prevail while valley winds are variable. An isohyetal map of the basin shows isohyetal lines indicating annual precipitation varies from 10 to 45 inches (for the period 1944-1968).

Geology

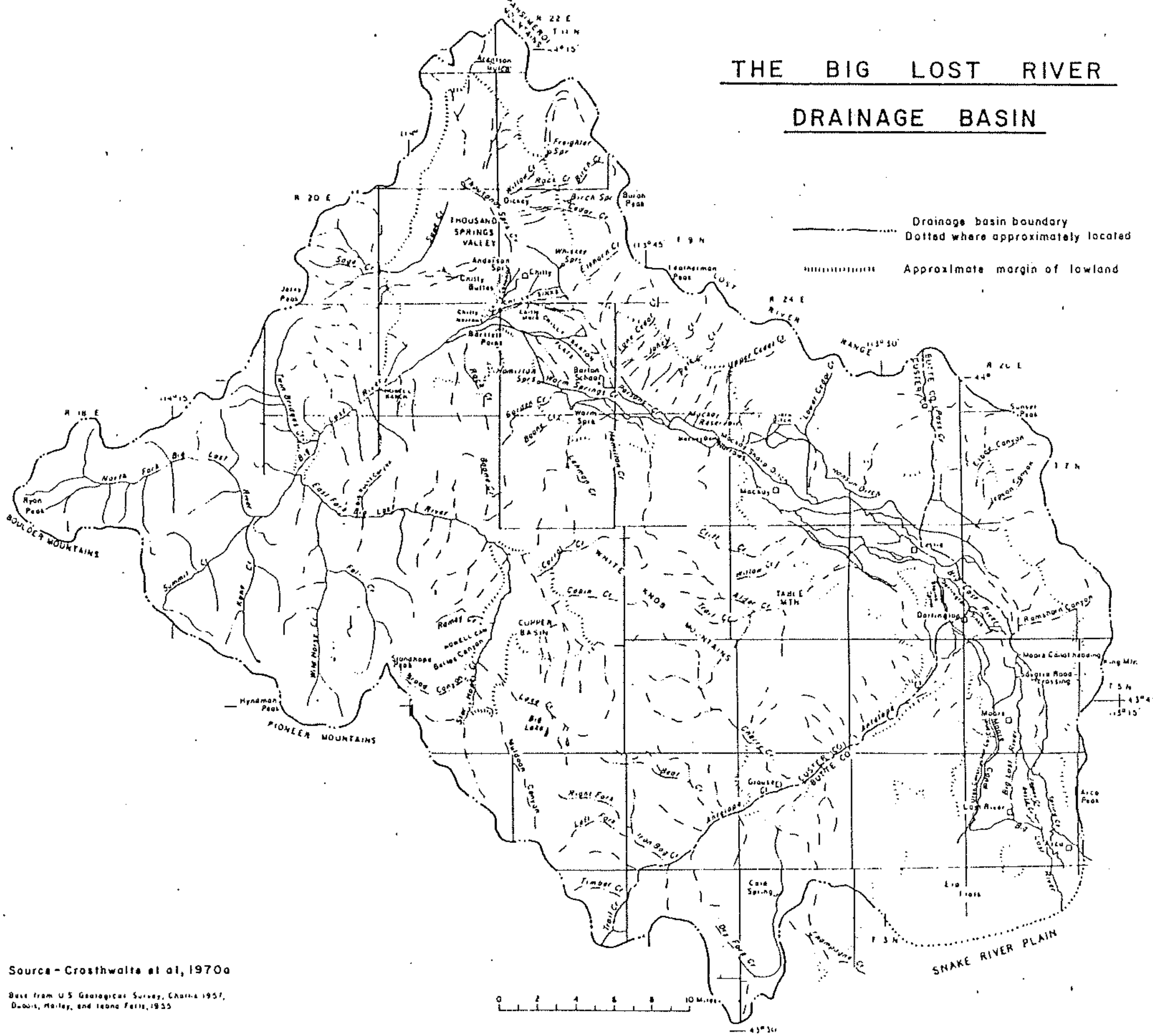
The geology has been discussed in Crosthwaite, et al. (1970a) and in Crosthwaite (1973).

The uplands are composed of a sedimentary sequence of limestone, dolomite, quartzite, sandstone, shale and argillite. Intrusions of granitic rock occurred at some places into the sedimentary units while volcanic materials cover an extensive area of the higher sedimentary rocks. Basalt from the Snake River Plain is found at the surface in the south end of the

THE BIG LOST RIVER DRAINAGE BASIN

Drainage basin boundary
Dotted where approximately located

Approximate margin of lowland



Source - Crosthwaite et al, 1970a

Base from U.S. Geological Survey, Challis 1957, Dubois, Hailey, and Idaho Falls, 1955

Fig 1

Big Lost River basin; it exists also as subsurface flows by and north of Arco, Idaho.

Alluvium is present in two forms, cemented and unconsolidated. A calcite cement binds together fragments of sandstone, quartzite and limestone of the old alluvial fans. The unconsolidated materials are composed of clay to boulder size particles and, in places, range greatly in the degree of sorting. Geophysical information indicates that these deposits are from 2000 to 3000 ft. thick in the Thousand Springs and Barton Flats areas (Figure 1). An alluvial fill over 5000 ft. thick is known to occur in the area east of Mackay, Idaho. The fill thins from Leslie southward until, near the mouth of the valley at Arco, it may be about 2500 ft. thick.

Hydrogeologic Characteristics of Earth Materials

All materials in the basin can contain and transmit water in varying degrees. At the higher elevations, recharge occurs in the fractures of the consolidated rock units. Some of the water is discharged to streams, sustaining their flows in dry periods. Another portion of the ground water continues down slope entering the valley alluvium and may not enter surface water courses. Numerous streams lose all their flow to the highly permeable colluvial and alluvial fans found at the edge of or near the valley floor.

Precipitation on the valley floor and stream channel losses are the two other primary sources of recharge to the ground-water reservoir. Additional recharge occurs from irrigated lands.

Natural discharge of ground water occurs into gaining reaches of the Big Lost River, as springflow, as ground water leaving the basin south of Arco, and as evapotranspiration where the water table is at or near the land surface. Ground water is also artificially discharged through wells.

By far, the most important aquifers in the basin are those made of coarser materials in the valley alluvium. The valley fill is very heterogeneous, especially away from the flood plain of the Big Lost River and toward the edges of the valley. Within many areas of the flood plain, older alluvium has been reworked by the river so that thick deposits of sands and gravel occur.

While water table conditions are present in the valley, localized perched and artesian conditions are also known. The great variability in the sediments accounts for this. It appears the basin has widely scattered lenses of low permeability materials that allow perched and artesian zones to develop. The areal extent of these lenses is not defined at present.

Surface Water-Ground Water Interactions

In the Big Lost River basin, several naturally occurring areas of exchanges between surface water and ground water are known. Great volumes of water vanish into permeable materials in the Chilly, Darlington, and other sinks and emerge in the channel above Mackay Narrows, above Moore Canal heading, and in other reaches. Figure 2 shows, in a relative, unquantified way, these changes. In addition to natural fluxes, there are also effects produced by irrigation wells. Where such wells are near the main

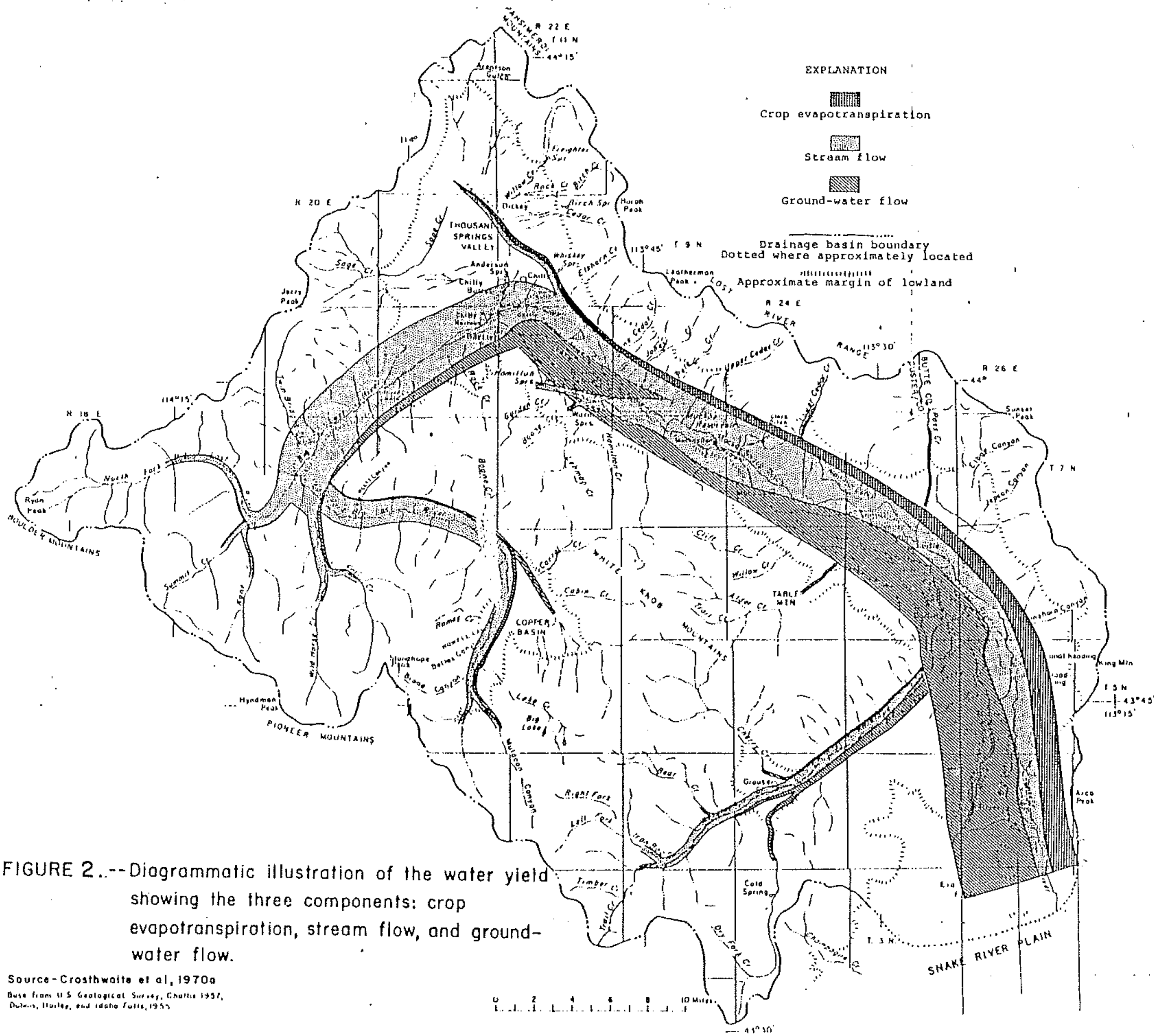


FIGURE 2.--Diagrammatic illustration of the water yield showing the three components: crop evapotranspiration, stream flow, and ground-water flow.

Source-Crosthwaite et al, 1970a

Base from U.S. Geological Survey, Challis 1957, Dubois, Hailey, and Idaho Falls, 1955 river channel and are completed in materials that are hydraulically connected with the river, there is stream depletion by wells. The depletion occurs primarily in T5N R26E and southward to a point just upstream from Arco. From there the river begins to lose water to the ground-water reservoir of the Snake River Plain and never again regains ground water. Other reaches where the river may lose appreciable volumes of water are shown in Figures 3 and 4.

Uses of Water

Water is used for domestic, stock and agricultural purposes. The last use is the largest of the three. While, in the past, the river was the primary source of water for agriculture and was measured at diversion points, there is now no adequate program of measurement. As the surface water resource approached, a fully appropriated status, farmers turned to the development of ground water for irrigation. Ground water was also developed to supplement the surface-water supply in drier years.

Interest in previously irrigated land southwest of Arco (in T3N R26E) has led to the practice of pumping ground water in an upstream part of the basin, putting it into a canal, and moving it to a more southern locale where it is diverted for irrigation. Some water users are very concerned about this practice. They fear that water levels in nearby wells may be lowered. While no field study has been conducted to verify this for existing wells near well involved in such canal transfer of water, it is obvious

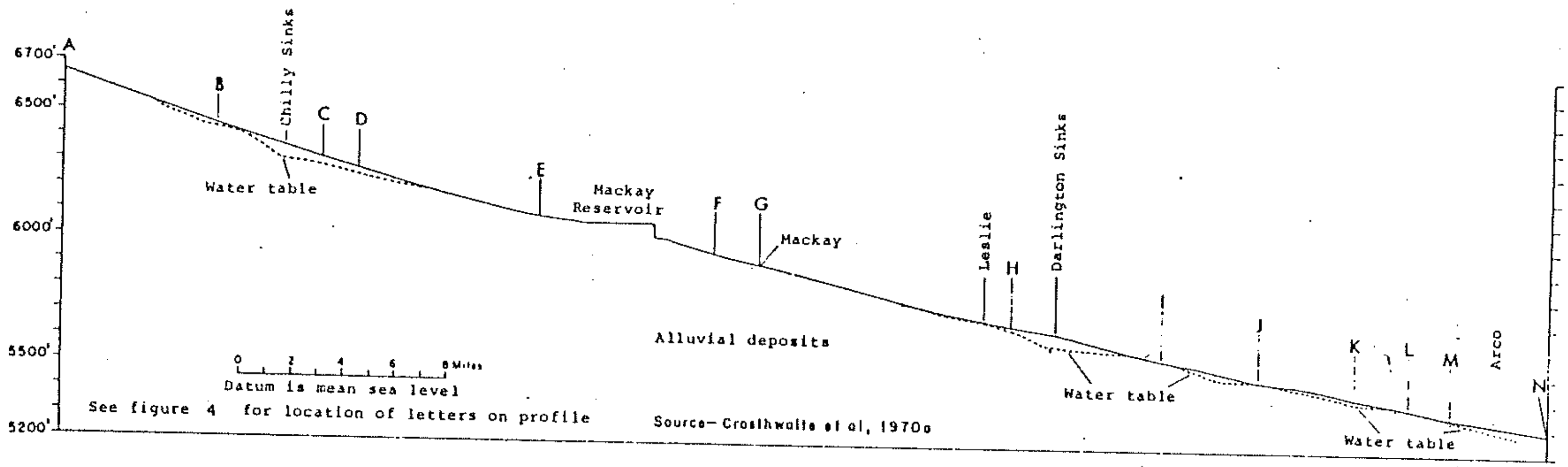


FIGURE 3---- Profile of Big Lost River showing the position of the water table.

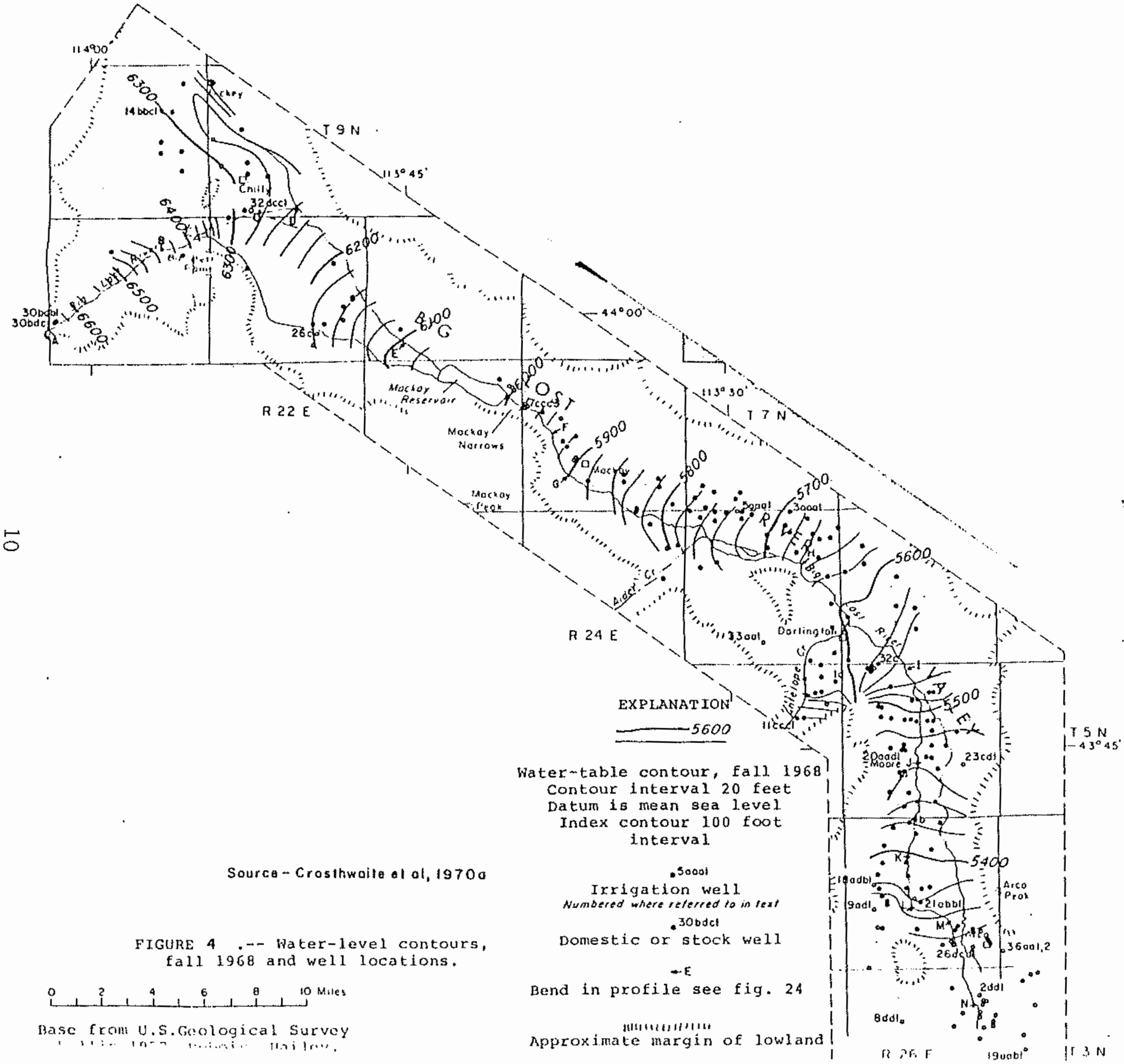


FIGURE 4 .-- Water-level contours, fall 1968 and well locations.

that the area around the well receives no benefit of recharge. While there are transmission losses from the canal that carries the water away, the major portion of the pumped water could be considered as a consumptive loss to the area around the well.

Information on the wells in the basin is found in Table 1 and Figures 5 and 6 show the well distribution in part of the basin.

Ground-Water Level Changes

As part of the 1970 USGS study, seasonal changes in water levels were monitored from July 1966 to September 1968. These observations were made in selected wells from the Chilly Sinks area to the Butte City area, southeast of Arco. Usually, lowest levels were observed in late winter and early spring when streamflow is at a minimum and canals are empty. From midsummer to early autumn, the levels were highest when river flow is larger and canals are full.

Within the basin, the USGS makes observations now in six wells; one is in Thousand Springs Valley at the upper end of the basin, another well is found in T6N, R25E, and the others are near the mouth of the basin; some of these are shown in Figures 5 and 6. Hydrographs for these wells are included as Figures 7 to 12. Those hydrographs of special interest are for wells located in T4N and T5N, R26E, and area in which the use of ground water has increased greatly in recent years. The five observation wells in T2 and 3N are presented since these may reflect either changes in the Big Lost basin, or alterations in the Snake Plain

TABLE 1. WELLS IN THE BIG LOST RIVER VALLEY[1/]

Township	Number of Wells			Range of Depths, in feet		
	Irrig.	Domestic	Others[2/]	Irrig.	Domestic	Others[2/]
9N-21E	4	1	0	267-433	95	---
9N-22E	1	2	2	150	42,51	49,53
8N-21E	0	2	2	---	32,37	38,127
8N-22E	4	3	3	86-135	44-88	26-56
8N-23E	1	2	0	105	30,50	---
7N-23E	0	3	1	---	70-82	98
7N-24E	13	19	6	30-152	20-180	42-398
7N-25E	6	0	0	120-297	---	---
7N-26E	1	0	1	91	---	468
6N-24E	5	3	0	99-245	36-57	---
6N-25E	28	15	0	63-233	30-80	---
6N-26E	9	8	1	55-250	43-120	19
5N-25E	7	0	1	180-251	---	108
5N-26E	28	14	3	110-250	40-220	68-174
4N-24E	0	1	1	---	34	110
4N-25E	1	3	4	30	51-180	60-300
4N-26E	50	27	4	18-272	39-169	51-320
3N-25E	0	0	4	---	---	300-416
3N-26E	7	16	0	61-840	30-170	---
3N-27E	1	5	2	85	55-550	72-850
TOTALS	166	124	35			

1/ As of August 3, 1982; source: IDWR well logs on file.

2/ Includes stock, test, observation and municipal wells.

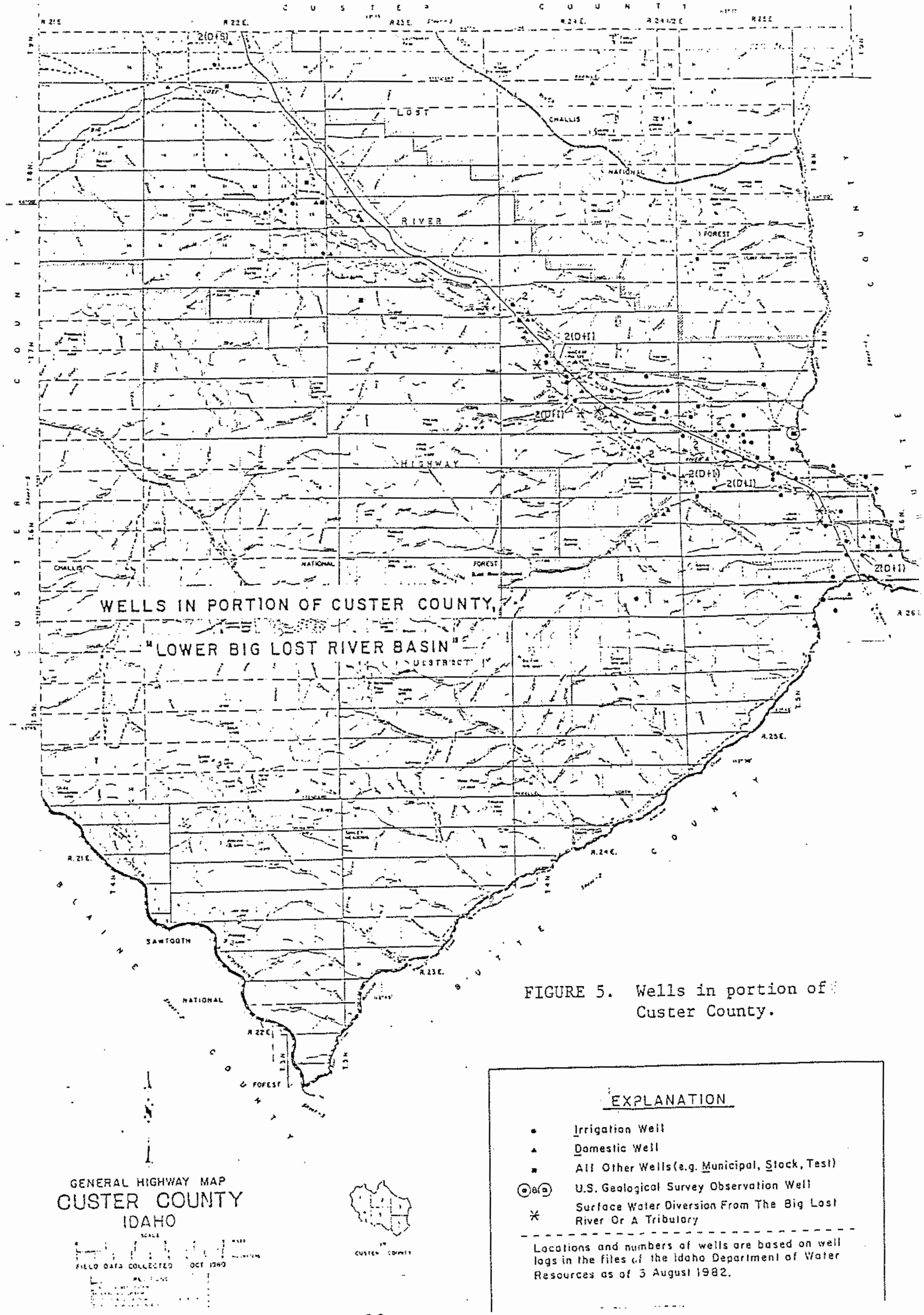


FIGURE 5. Wells in portion of Custer County.

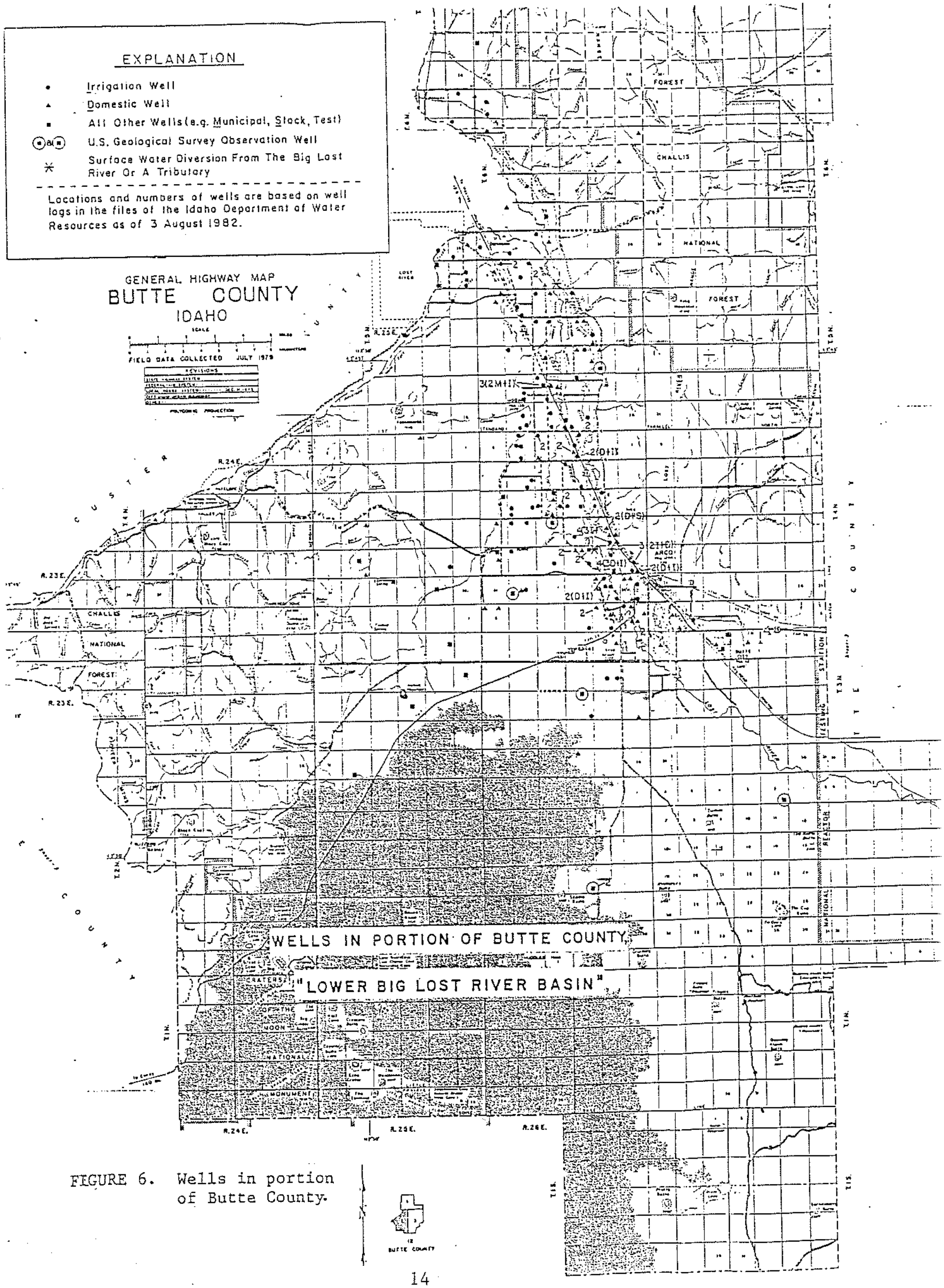


FIGURE 6. Wells in portion of Butte County.

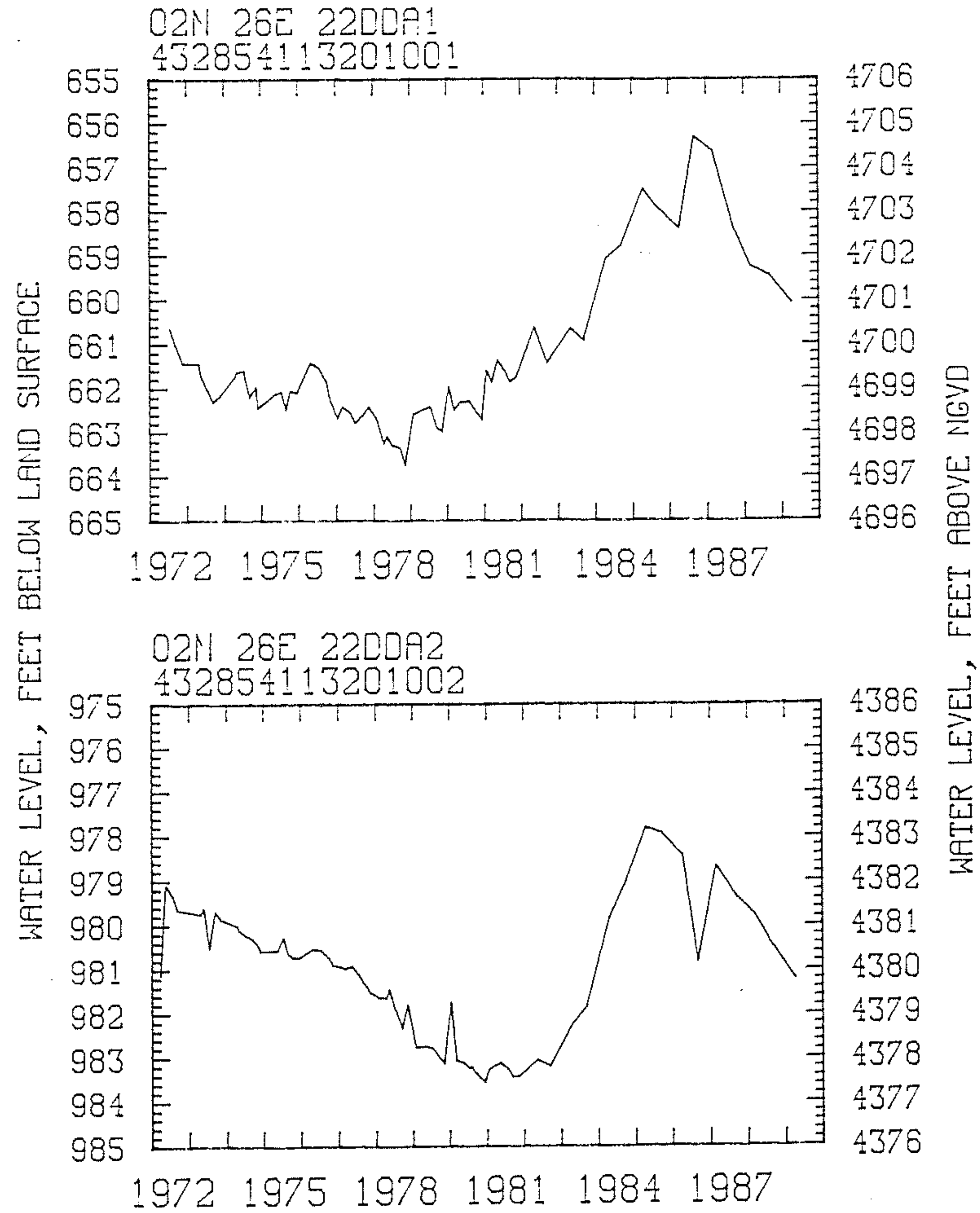


FIGURE 7. Hydrographs of wells 02N26E22DDA1 and 02N26E22DDA2.

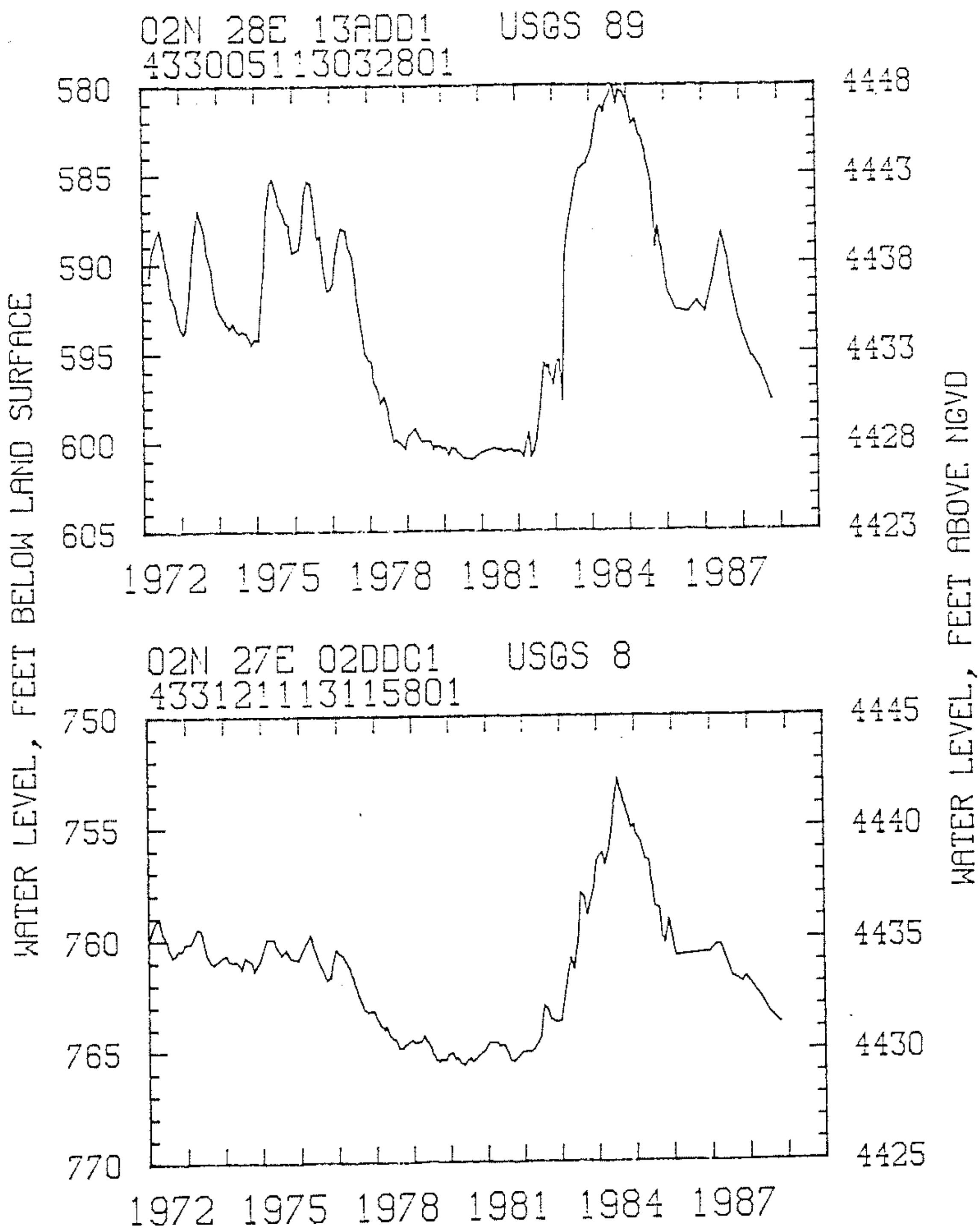


FIGURE 8. Hydrographs of wells 02N28E13ADD1 and 02N27E02DDC1.

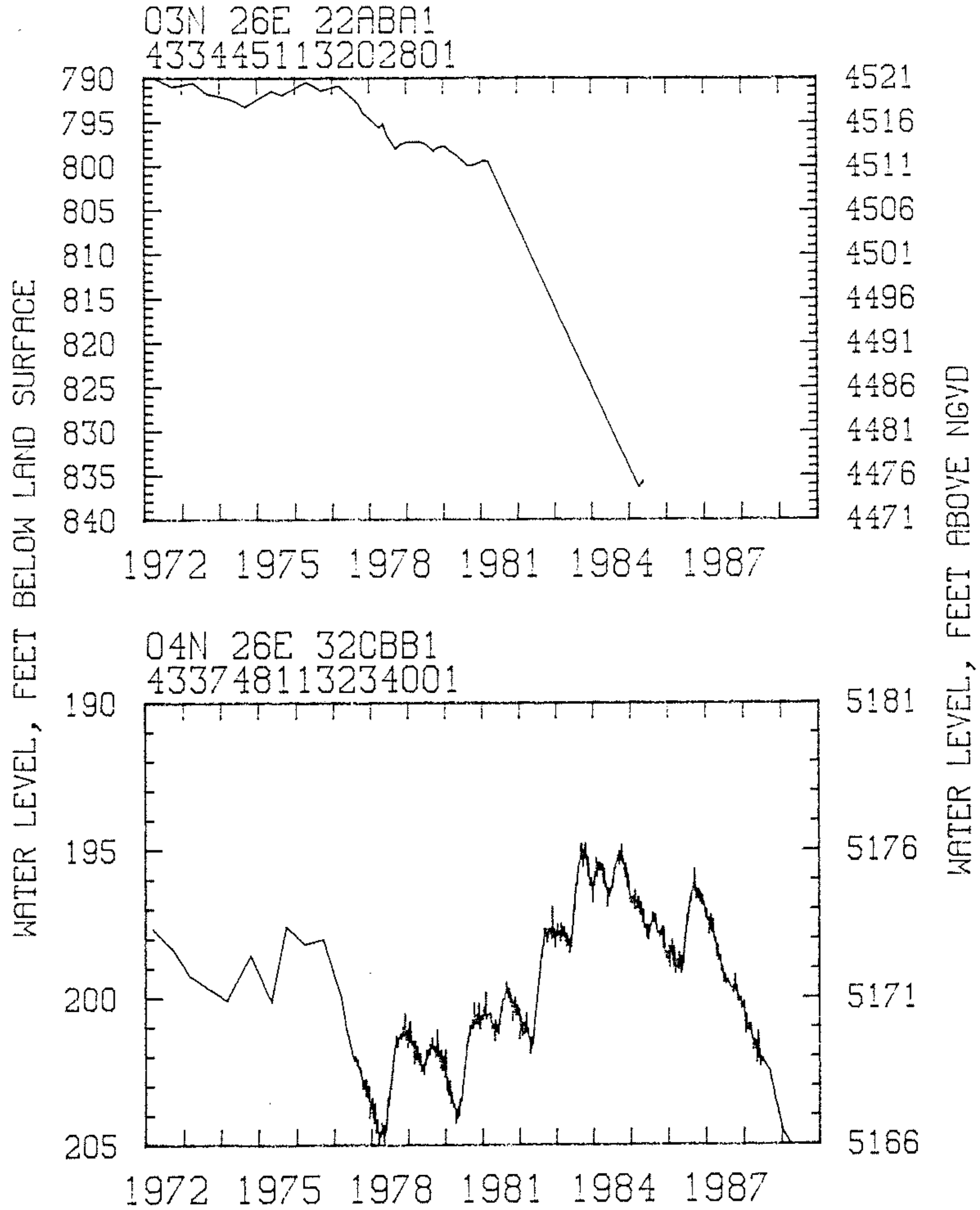


FIGURE 9. Hydrographs of wells 03N26E22ABA1 and 04N26E32CBB1.

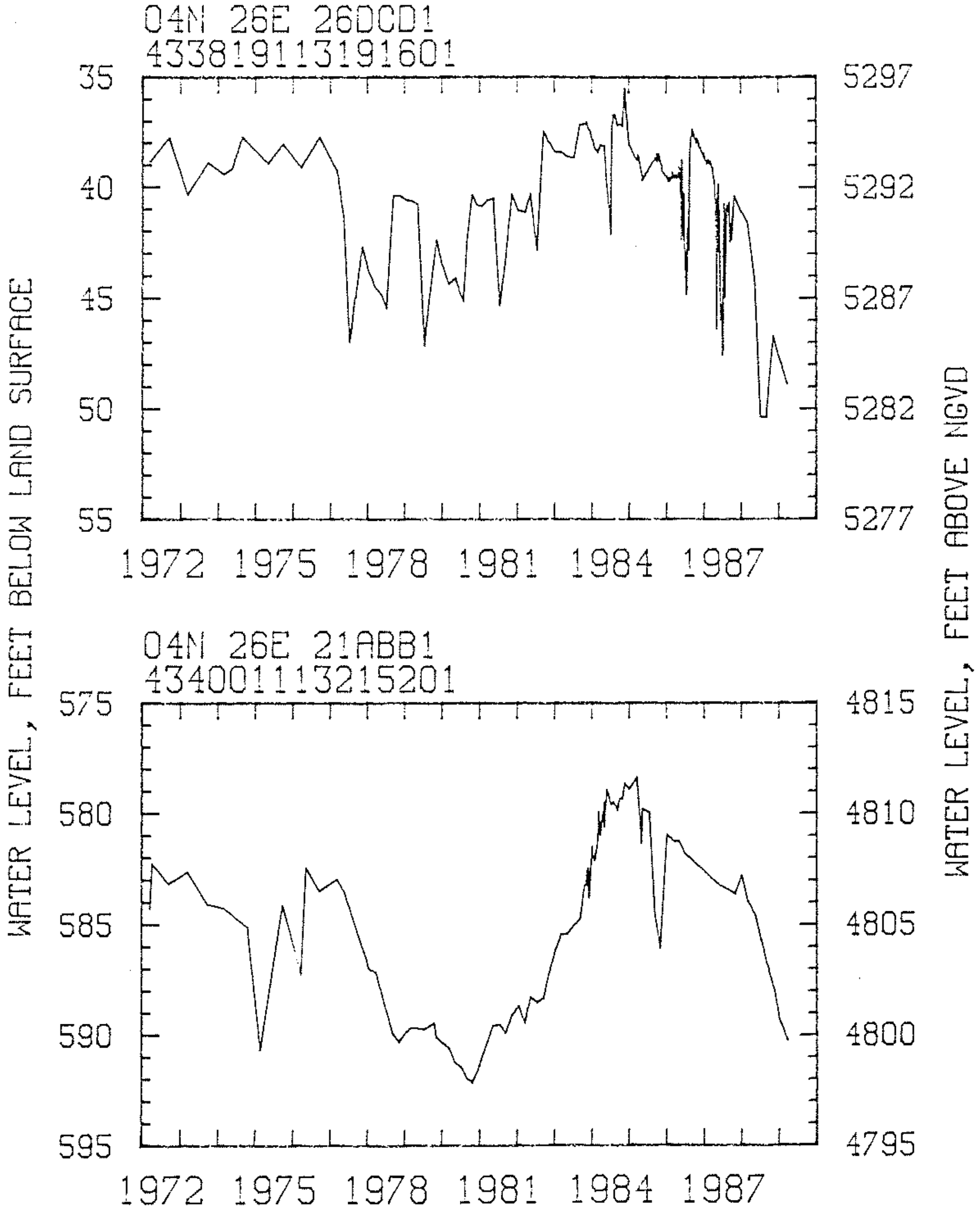


FIGURE 10. Hydrographs of wells 04N26E26DCD1 and 04N26E21ABB1.

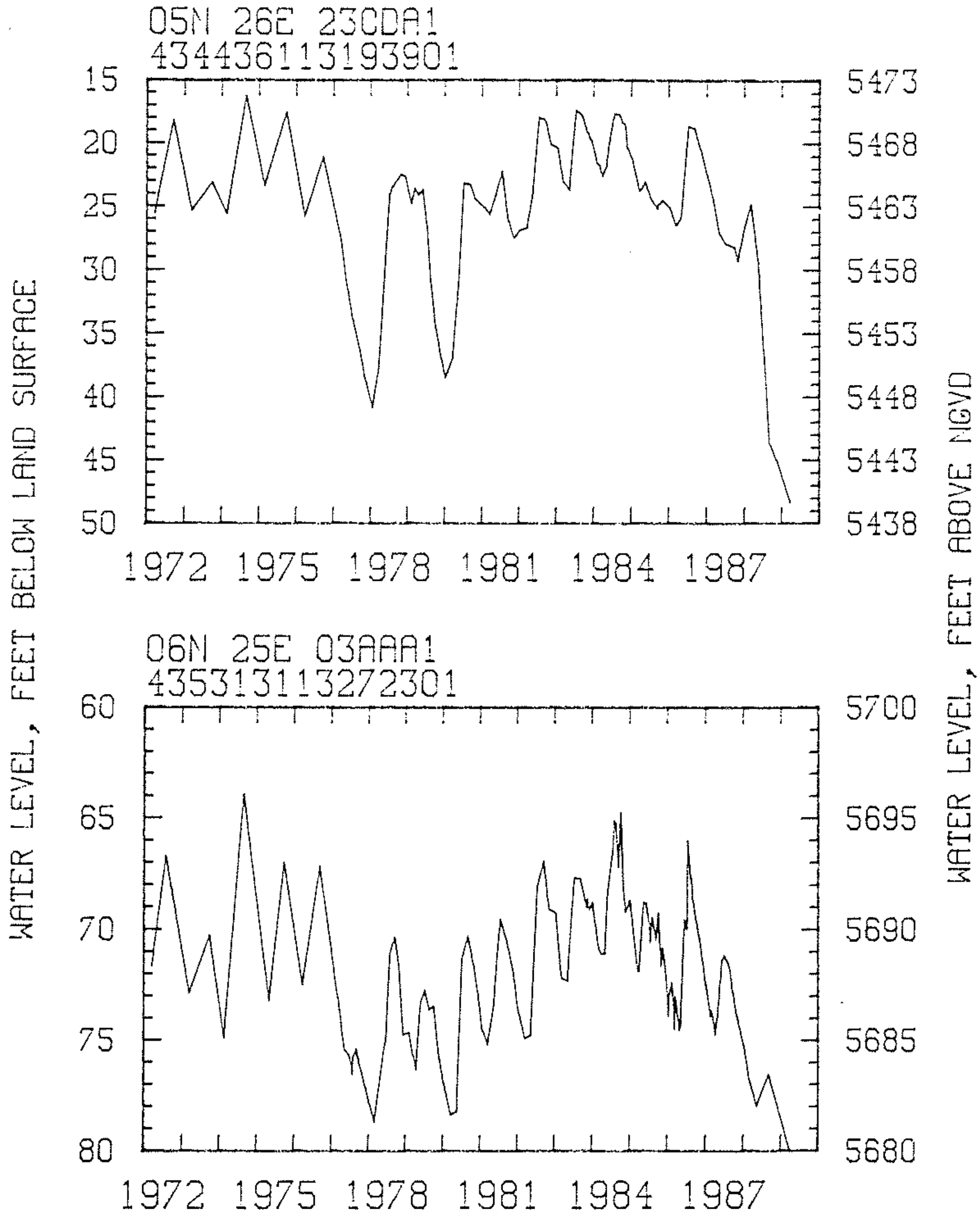


FIGURE 11. Hydrographs of wells 05N26E23CDA1 and 06N25E03AAA1

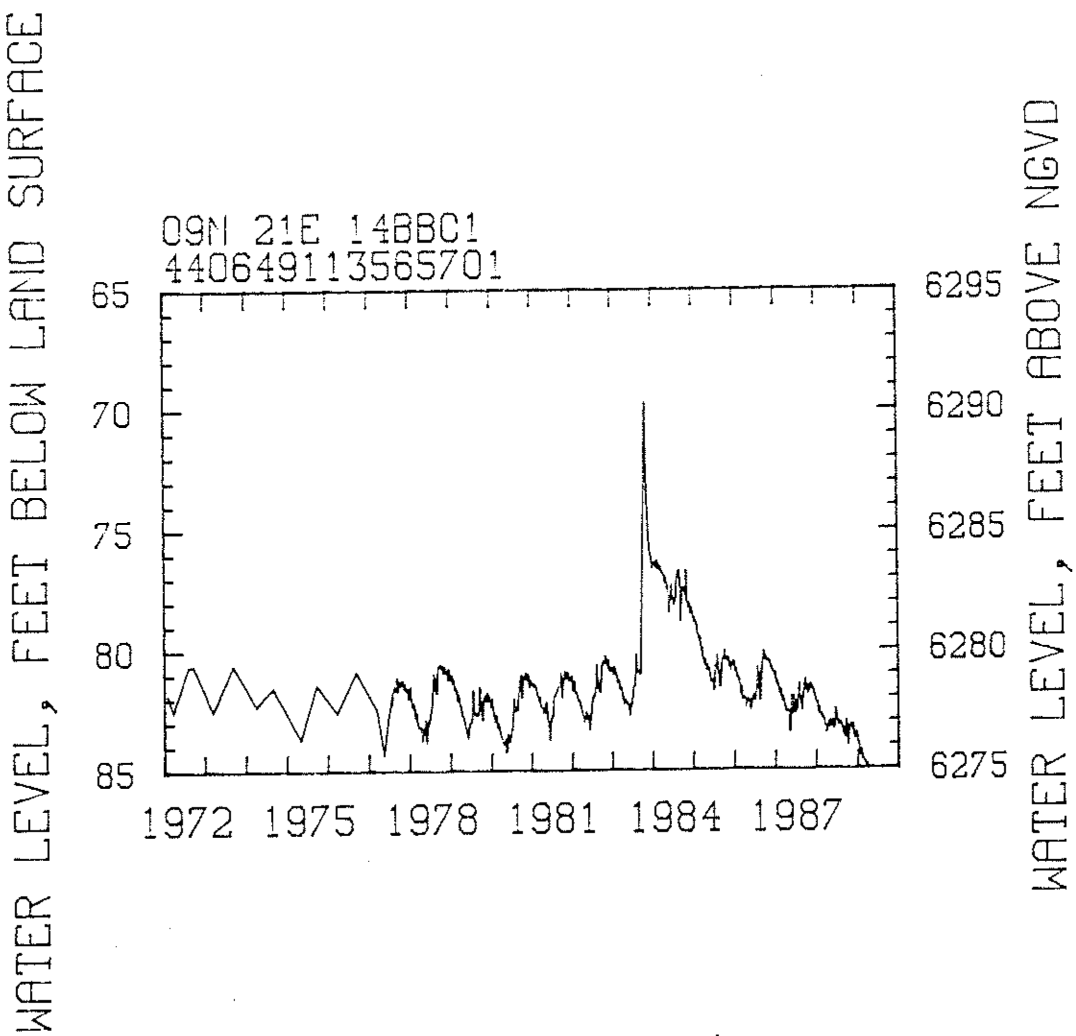


FIGURE 12. Hydrograph of well 09N21E14BBC1.

aquifer caused by increased development of ground water for irrigation or, perhaps, long-term changes from climatic trends affecting the upper Snake River and tributary basins.

Ground-Water Flow Leaving the Valley

From a point about two miles northwest of Arco, the Big Lost River begins to lose its entire flow to the ground water of the Snake Plain aquifer. Underflow from the Big Lost River Valley also moves southward to enter the Snake Plain aquifer. The 1970 USGS study reported that 425 cfs is the ground-water outflow at the mouth of basin south of Arco. In his 1978 thesis, Newton calculates that 227 cfs passes Moore as ground-water underflow. Down gradient from the Moore area there are wells which penetrate this flow, reducing it by an unknown degree. The cross section in Figure 13 shows the sharp drop in the water table as the alluvium of the valley connects with the highly permeable basalts of the Snake Plain aquifer. If adjustments were to be made to Newton's figure, to include the added ground-water recharge from the river and canals, then the two estimates might be rather similar.

Water Management Possibilities and Options

Ideas Crosthwaite (1970 a and b) presents for water management rest entirely upon the recognition that surface water and ground water are not independent of each other but are directly associated. This understanding leads to proposals of conjunctive use management, something which Crosthwaite mentions frequently.

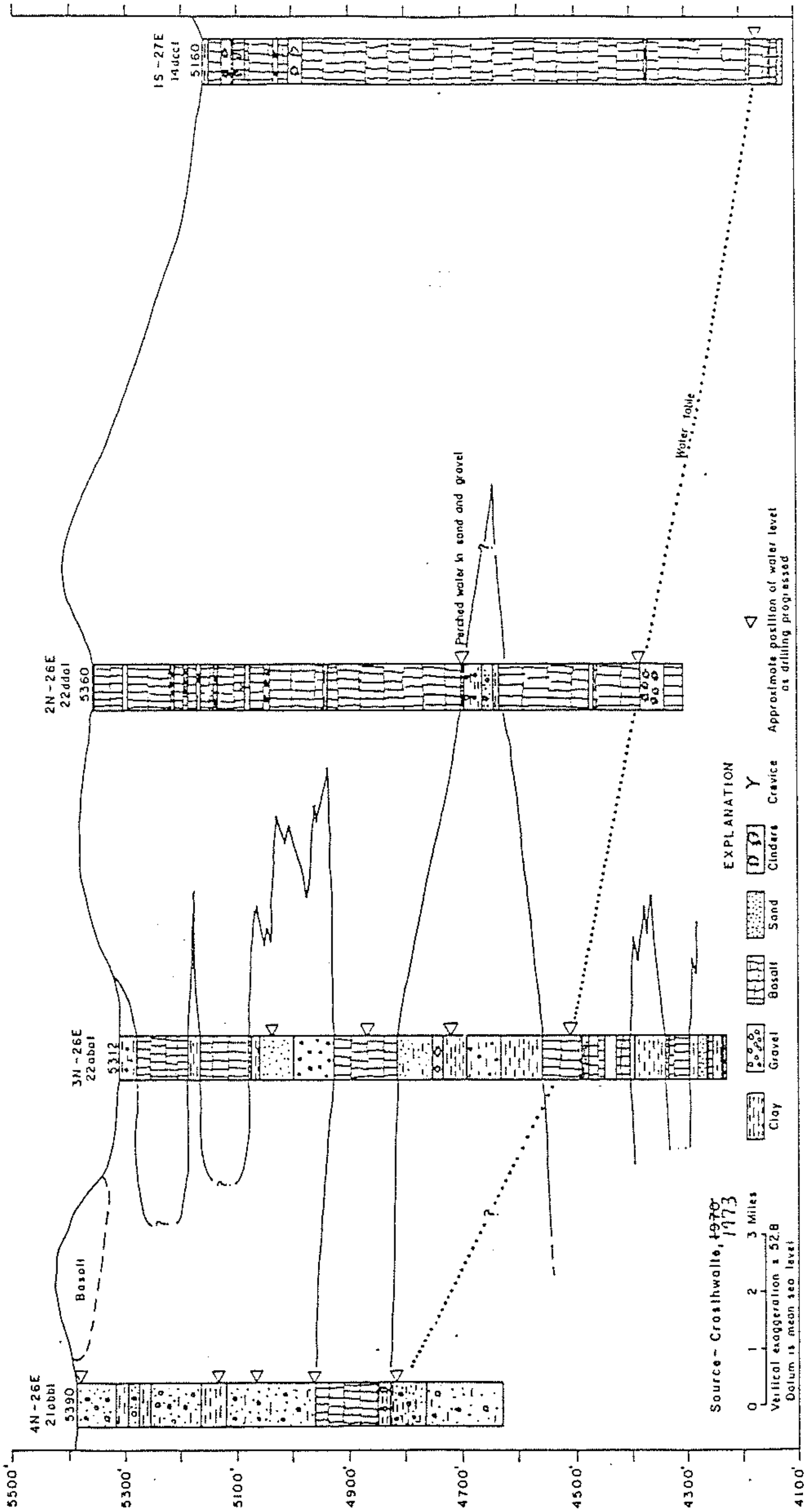


FIGURE 13. Geologic section through observation well near Arco.

Considering first those measures that would either increase surface water storage, improve the efficient use of surface water or detain surface water for useful application, Crosthwaite proposes:

1) Pumping water, leaking as ground water from Mackay Reservoir back into the reservoir; diverting Lower Cedar Creek to Mackay Reservoir; lining the channel of upper Cedar Creek to Mackay Reservoir.

2) Constructing reservoirs upstream from Mackay Reservoir and using the stored water in a recharge distribution system in the Chilly Sinks area. This recharge to ground water would move into the upstream end of Mackay Reservoir and could be timed so that it would enter the reservoir during times of peak irrigation use. Upstream storage would diminish the adverse effects of flood flows by allowing controlled release of stored surface water to the permeable materials in the Chilly-Barton Flats area where recharge of the ground-water system would occur. Use of the old Utah Construction Co. canal to convey flood flows to the basalt lava plain south of Arco would also be beneficial.

3) Improving surface water irrigation efficiencies and application techniques. Using sprinklers, lining canals, leveling the land, having better control of the length of time water is applied and carefully choosing the length of furrows are steps to insure lower losses

from the surface water system and to reduce the consumptive use of water by phreatophytes that would otherwise grow along water distribution systems. One of the USGS reports (Crosthwaite et al., 1970b) states that the loss of recharge to the ground-water reservoir from the use of these methods would be an insignificant factor since annual recharge is great.

Regarding ground-water management options, the USGS reports offer the following:

1) While ground water removed from the alluvium between Arco and Moore could be used to irrigate the Era Flats, the pumping would adversely affect surface water flows in this same stretch of the basin. According to limited USGS work done in the 1960's, it seems likely that a deep basalt aquifer and the underlying alluvium, located northwest of Arco, would be a better of source of water since pumping from these aquifers would have less of an undesirable influence on the river. However, the water yielding ability of these aquifers is unknown.

2) Pump ground water from the Chilly area to the upper end of Mackay Reservoir into the reservoir (via lined ditches or pipelines) to augment the storage in the reservoir, making it available later during irrigation season.

3) Recharge excess surface flows during the period April to June into the highly permeable materials in the Chilly-Barton Flats area. This water dispersed from the Big Lost River into canals and ponds would be discharged from the ground-water system into Mackay Reservoir.

4) Divert surface water below the reservoir, into canals in the late winter-early spring, in order to recharge the sides of the basin.

Conclusions

From understanding of the 1970 USGS reports, I conclude that:

1) Above all else, the surface-water and ground-water systems act interdependently, with a change in one that soon affects the other. The uses of ground water and surface water appear to be in greatest conflict through the pumping in the shallow, localized ground-water system along certain specific river reaches. This is manifested by stream depletion due to the pumping of wells near the river. The effects of depletion are most rapid and severe on streamflow from wells that are shallow and are completed in highly permeable earth materials, yield a large amount of water, are operated for a long length of time, and are close to the river.

2) Considering the total water yield of the basin, there is certainly no shortage. However, it must be expected

that the pumping of the ground-water system will continue to create imbalance of varying degrees with surface-water supply. This is so because of differing water supply needs among irrigators (i.e., both quantities and length of time wells are pumping). The cumulative effect upon the river and its users from many wells cannot be easily predicted.

3) Although the USGS 1970 reports indicate that wells along certain reaches of the river will not directly affect river flow, it is believed, based on conclusion 1 and fundamental hydrogeologic principles, that ground-water development, occurring in areas where the river is above and not connected with the underlying water table, would alter the ground-water hydraulic gradient. In areas upstream, recharge to the ground-water system furnished by the river would increase and in areas downstream, recharge to the river supplied from the ground-water system would decrease. The net effect then is surface flow reduced by some degree. Below Arco, pumping from the deep regional aquifer should not affect the river flow.

4) The USGS reports point out several shortcomings in the management options listed previously in this study. With the surface-water shortage upstream of Mackay Reservoir, there have been no detailed analyses of storage capacities nor of benefit-cost ratios of

reservoir construction and operation. In addition, there have been periods when all surface water and tributary ground water upstream from Mackay Reservoir were committed totally to the filling of the reservoir. One of these periods lasted for 10 years. This indicates that replacement schemes using water upstream from the reservoir would not accomplish the desired replacement. For the same reason, the recharging of the Chilly-Barton Flats would not actually be replacement and could cause high water tables just upstream from Mackay Reservoir, so that farming operations would be retarded. In the pumping of the Chilly Flats area to furnish piped or conveyed (without leakage) water to Mackay Reservoir, the swampland in Thousand Springs Valley and in the area just upstream from the reservoir would shrink; crops grown in these tracts, where subirrigation apparently furnishes water to the plants now, would be irrigated with pumped ground water. Lastly, in the plan to recharge the lower basin by running high surface flows in canals from late winter into early spring, it is thought that this water would not be retained sufficiently long in the earth materials but rather would move quickly into the lowlands along the river, recharge the river, and interfere with the cultivation of crops in the low lying lands.

Perhaps the most vexing aspect though, in the ground-water proposals especially, is that no one knows how the priority system of water rights might be upset. As the reports frequently point out, the Big Lost basin is an ideal one for conjunctive use of water despite the recognition that water users may not be eager to convert to an innovative system of water management. If this or any other management approach is to be undertaken, it is essential that the diversions of surface water be adequately measured. Withdrawals from existing exchange wells should also be measured. A great deal of information on use and time-effect relationships would be needed before conjunctive use could ever be pursued.

5) Despite the fact that ground water is leaving the basin below Arco, to utilize it upbasin from Arco will lead so some cumulative reduction in surface flow in downstream areas. The closer to Arco that any future ground-water uses for irrigation are restricted means that losses in surface water flow will be minimized. The Big Lost River gains no important contribution of ground water south of Arco.

BIBLIOGRAPHY

Bureau of Reclamation, U.S. Department of the Interior, Corps of Engineers, U.S. Army Engineer District, 1961: Upper Snake River Basin, Volume 1, Summary Report.

Crosthwaite, E.G., 1973: A Progress Report on Results of Test-Drilling and Ground-Water Investigations of the Snake Plain Aquifer, Southeastern Idaho: Part 2, Observation Wells South of Arco and West of Aberdeen, Idaho Department of Water Resources, Water Information Bulletin No. 32, 60 p.

Crosthwaite, E.G., 1981: personal communication.

Crosthwaite, E.G., Thomas, C.A. and Dryer, K.L., 1970a: Water Resources in the Big Lost River Basin, South-Central Idaho, Open-File Report, U.S. Geological Survey, 109 p.

Crosthwaite, E.G., Thomas, C.A. and Dryer, K.L., 1970b: Considerations for Water Use and Management in the Big Lost River Basin, Idaho; A Supplemental Report; Open File Report, U.S. Geological Survey, 15 p.

IDWR well log reports.

Newton, G.D., 1978: Application of a Simulation Model to the Snake Plain Aquifer, MS Thesis, University of Idaho, 82 p.

Parliman, D.J., 1982: Ground-Water Quality in East-Central Idaho Valleys; U.S. Geological Survey Open-File Report 81-1011, 62 p.

Stearns, H.T., Crandall, Lynn and Steward, W.G., 1938: Geology and Ground-Water Resources of the Snake River Plain in southeastern Idaho, U.S. Geological Survey Water-Supply Paper 774, 268 p.

Whitehead, R., 1981: personal communication.